Space Weather Technical Forecast

Issued on Tuesday, 23 May 2023 at 01:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further R1/R2 radio blackouts likely. G1 Minor/G2 Moderate storms likely day 1 (23 May). Active fluence likely from late day 2 (24 May)

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with peak flare of M1.9 at 21/1604UTC from AR3312. This is a small region in the southeast disc that has subsequently decayed further. The most complex region AR3311 in the northeast quadrant, consists of a wide train of small umbral regions, including a small delta spot within its intermediate regions. However this has seen ongoing separation and very gradual reduction in spot numbers, indicative of a stabilisation process. AR3310 is a further large region in the southeast, dominated by a large umbra with much smaller surrounding spots that have shown some evolution and development in the last 24 hours. Despite this, activity has remained limited. AR3305 has now rotated over the western horizon and is no longer visible. The other regions are all smaller and simple to give at total of six sunspot regions on the disc.

A weak CME was produced by the M1.9 flare, off the southeast disc. This has been analysed as missing, but likely passing close to the Earth late on 26 May. No other Earth-directed CMEs have been observed.

Solar Wind / Geomagnetic Activity: Solar wind speeds observed at L1 have been elevated at 500-600 km/s, perhaps due to a connection to the fast wind of CH06/-, although this is low confidence as the onset of these elevated winds currently appears to be too early for originating from this feature. Density was around average. The total IMF strength Bt, was Weak to Moderate, ranging from 4 to 11nT. The north-south component Bz was variable, but predominately negative, ranging from -9nT to +7nT. Phi angle was also variable for much of the day, however became mainly negative (towards the Sun) from 22/1400 UTC. Geomagnetic activity was mainly Unsettled to Active with one G1 Minor Storm interval 22/0000-0300 UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16 has remained at background levels throughout. High energy electron flux (greater than 2MeV), as measured at GOES16 was mainly at background levels until 22/1200, before rising to briefly peak at High, reaching 1270 pfu at 22/1615 UTC before falling back to background levels. The 24-hour integrated fluence has been below Active. The 22/0000UTC observed fluence was, 2.2e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate, with a chance of further M-class flares and only a very slight chance of X-class flares. The main risk region remains AR3311 in the northeast quadrant, due to the persistent delta spot, despite this spot showing signs of stabilisation.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs, although a weak CME passing nearby may give a glancing influence late on day 4 (26 May). Current elevated solar winds are expected to continue through days much of the period, only gradually easing by later day 3 onward. The current source of these winds is uncertain, but likely CH06/-, but also with a potential to still transition into the HSS from this feature through day 1 (23 May). Unsettled to

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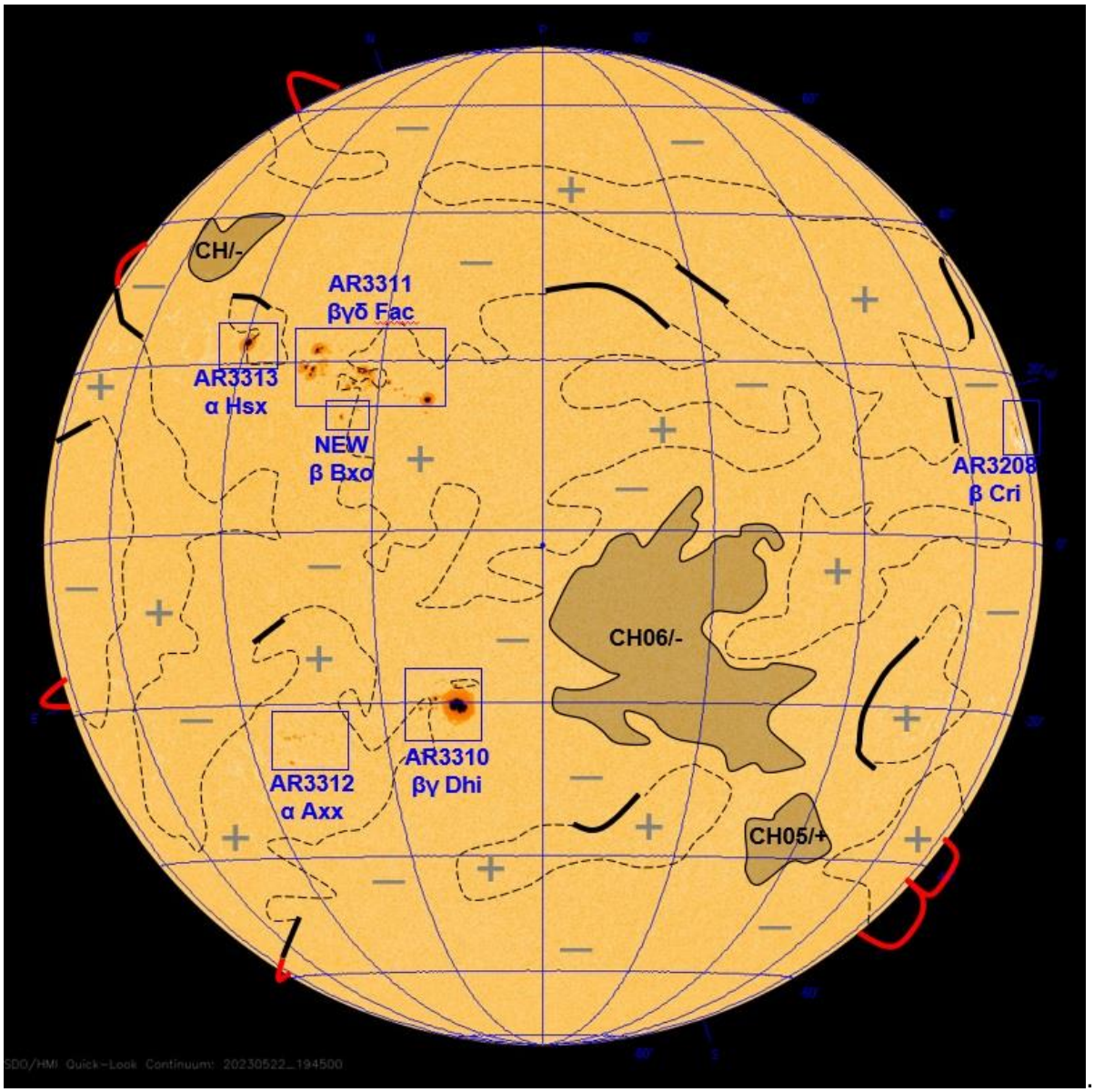
Active geomagnetic activity expected with a chance of G1/Minor Storms, mainly day 1 (23 May) but perhaps day 2 (24 May). Activity easing to mainly Quiet with Unsettled intervals, and a chance of isolated Active spells by day 4 (26 May).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to be at background, but carries a chance of rising in response to any large flares that occur, with a slight chance of reaching the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) will likely rise, erratically at first, but more persistently day 2 onward. This will give a likelihood of reaching the Active threshold by the end of day 2 (24 May), and more likely day 3 and 4 (25-26 May).

Figure 1. Solar Analysis Valid 22/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

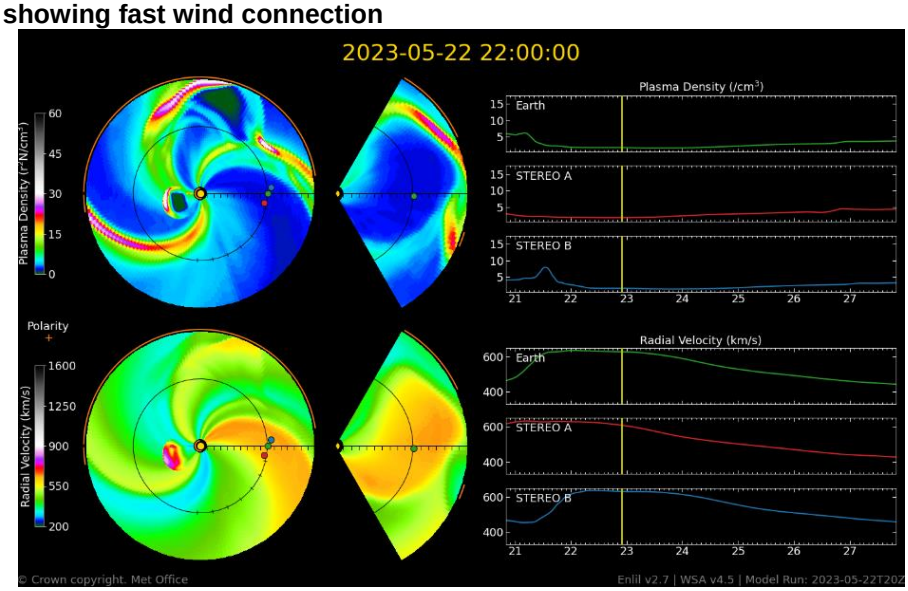
There are no Earth-directed CMEs, although a weak CME from the M1.9 flare of AR3312 at 22/1337 UTC is expected to pass close, to the south and behind Earth. Slight glancing influences cannot be completely ruled out late on day 4 (26 May).

Solar winds are currently elevated at Earth. The most likely source of this enhancement is the high speed stream (HSS) of CH06/-, a large feature now in the southwest disc and this is supported by enlil. However, the onset of these winds were much too early when compared to the typical location for the leading edge of such coronal hole sources. This brings some significant uncertainty to the source of the elevated winds, with the potential for a transition into this CH to still occur on day 1 (23 May).

Despite this uncertainty, largely elevated solar winds are expected through much of the period, likely around 550-650km/s, and only gradually easing day 3 and day 4 (25 and 26 May). This will bring mainly Unsettled to Active geomagnetic activity with a chance of G1/Minor Storms, mainly day 1 (23 May) but perhaps day 2 (24 May). Activity easing to mainly Quiet with Unsettled intervals, and a chance of isolated Active spells by day 4 (26 May).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	Yes	40	20	1	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: Enlil showing fast wind connection



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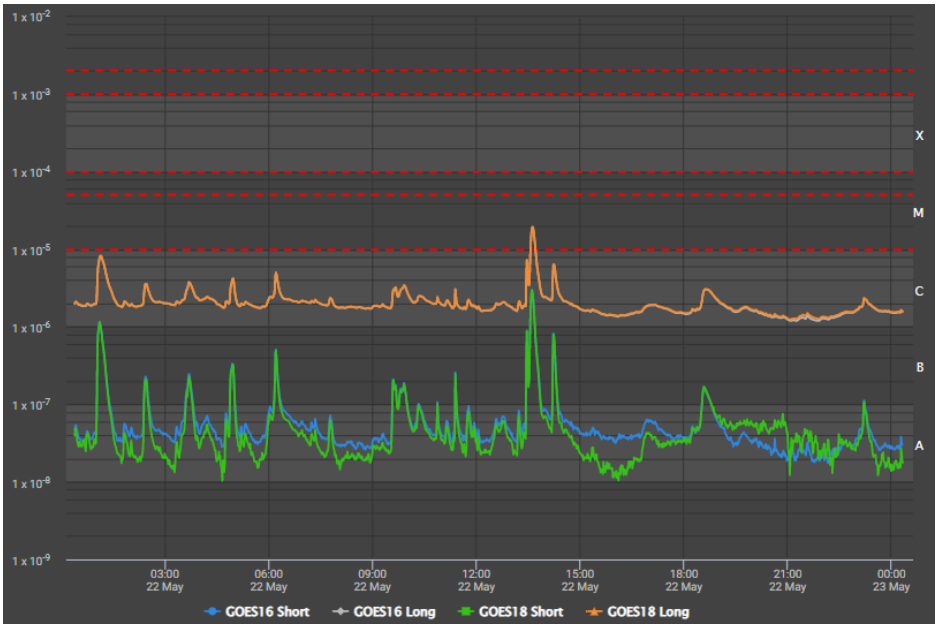
Radio Blackouts - X-Ray Flares:

Of the six regions on the disc, AR3311 remains the most complex, but with signs of slow simplification. The delta spot amongst its intermediate spots is becoming harder to see, and there has been both spreading and reduction of visible spots. This suggests a stabalising trend. Flux emergence has been observed around large spot AR3310, with the development of a couple of reverse polarity spots, along with small intermediate spots. This suggests the potential for complexification of the region, however this would be dependent on any further growth occurring. The other complex region, AR3305 has now rotated over the western horizon.

The other four regions, including a new emergence to the south of AR3311 remain smaller and simpler with no significant development or acidity. This includes the small and simple AR3312, which was the source of the largest flare in the last 24 hours.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	55	55	55	55
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16/18 X-ray Flux



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 has remained at background levels throughout and is expected to remain as such throughout the period.

There is the potential for some enhancement with the main risk from any larger flares from the complex region AR3311 as it rotates westward into the period, but also from regions that have now largely rotated to just over the western horizon on day 1 (23 May). As such a slight risk is maintained throughout.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) as observed at GOES-16 has varied from Background to briefly peak at High in the last 24 hours. This is as a consequence of the increase in electrons from the recent solar wind enhancements. However these enhancements have likely also suppressed the observed flux at GEO due to the compression of the Van Allen belt to below this level. While further solar winds enhancements are possible day 1 and into day 2 (23 and 24 May), these are low confidence, with a gradual easing of solar wind pressure expected. This will enable counts to rise at GEO, bringing more persistent Moderate, and increasingly long periods of High flux by day 2.

The associated 24 hour electron fluence is likely to remain below the Active threshold until day 2 (24 May), when there is an increasing likelihood of fluence rising above this level. This rising trend is supported by REFM, which is giving reasonable guidance up to T+24. Beyond this, REFM is currently below the expected observed fluence.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	30	60	70	70
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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